

National Aeronautics and
Space Administration



NASA Heliophysics GDC/DYNAMIC Overview

Canadian Association of Physicists Division of
Atmospheric and Space Physics

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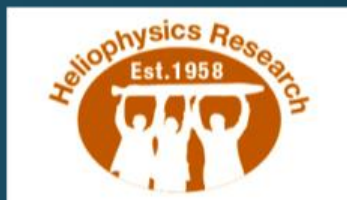
February 23, 2022

NASA Heliophysics Objectives

Solve the **fundamental physics** mysteries of heliophysics: Explore and examine the physical processes in the space environment from the Sun to the Earth and throughout the solar system including the interface with the interstellar medium.

Build the **knowledge to forecast space weather** throughout the heliosphere: Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Understand the **nature of our home in space**: Advance our understanding of the connections that link the sun, the Earth, planetary space environments, and the outer reaches of our solar system.





NASA Heliophysics Overview

Heliophysics Division (HPD)

- The scope of heliophysics is vast, spanning from the Sun's interior to Earth's upper atmosphere, throughout interplanetary space, to the edges of the heliosphere, where the solar wind interacts with the local interstellar medium
- Innovative cutting-edge missions in strategic locations throughout our solar system
- Includes PI-led/team focused research - modeling, data analysis, suborbital, balloon and CubeSat investigations, experimental/laboratory, facilities and instrument development, ...
- Vibrant in-house activities primarily at GSFC, with a smaller effort at MSFC
- Vibrant/growing external community
- Directed and competed approaches

HPD organization, guiding documents, and plans (near to long-term)

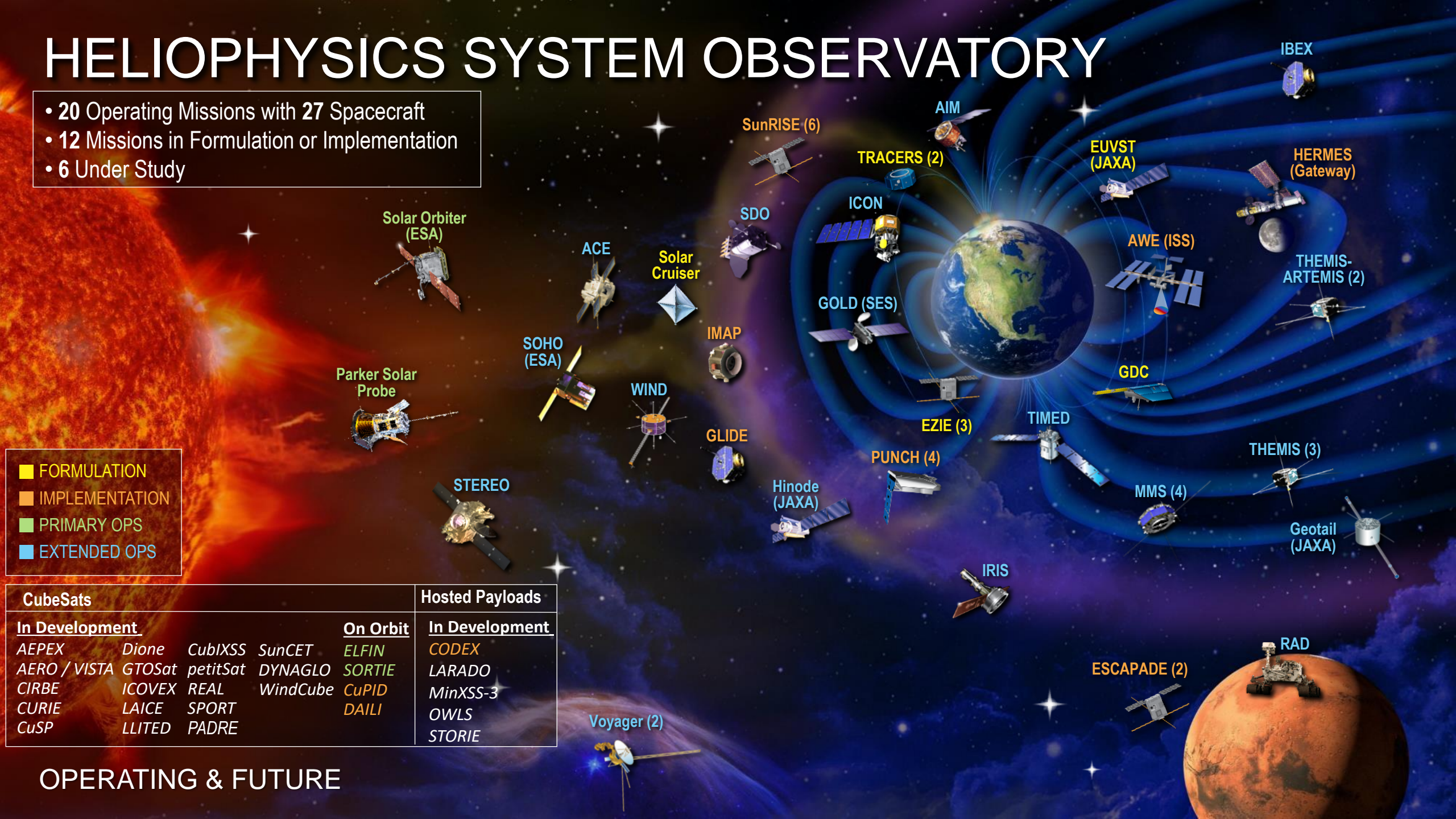
- Decadal Survey recommendations (2013) address research as well as science objectives for future missions
- SMD Science Plan (2020) – details HPD research organization, structure, objectives, and approaches (durable strategic objectives)
- National Space Weather Strategy and Action Plan inform research priorities and direction
- HPD Strategic Working Groups (SWGs)

Sustained, multipronged communication pathways

- Annual ROSES call lists solicitations for each current year
- HPD presence/presentations at most science team and community meetings
- Heliophysics Town Halls at major conferences (AGU, AMS, GEM, CEDAR, etc.)

HELIOPHYSICS SYSTEM OBSERVATORY

- 20 Operating Missions with 27 Spacecraft
- 12 Missions in Formulation or Implementation
- 6 Under Study



- FORMULATION
- IMPLEMENTATION
- PRIMARY OPS
- EXTENDED OPS

CubeSats				Hosted Payloads			
In Development				On Orbit			
AEPEX	Dione	CubIXSS	SunCET	ELFIN	CODEX		
AERO / VISTA	GTOSat	petitSat	DYNAGLO	SORTIE	LARADO		
CIRBE	ICOVEX	REAL	WindCube	CuPID	MinXSS-3		
CURIE	LAICE	SPORT		DAILI	OWLS		
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OPERATING & FUTURE

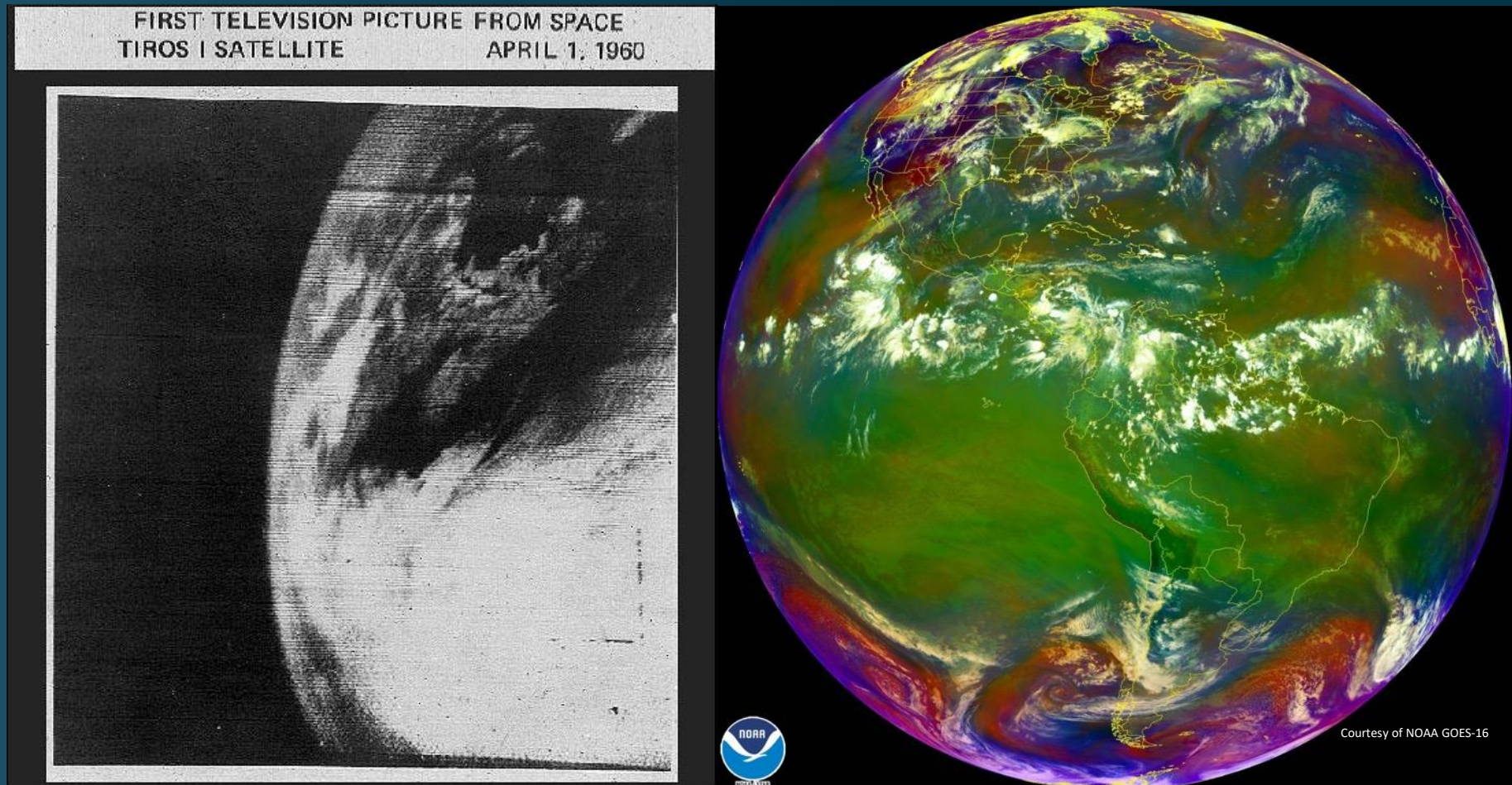
The background of the slide is a dark blue space-themed image. On the left side, there is a vertical strip showing a celestial scene with a bright yellow sun at the bottom, a blue and white Earth horizon, a grey crescent moon, a reddish-brown Mars, and a yellow Saturn with its rings at the top. The main area of the slide is a solid dark blue.

Geospace Dynamics Constellation (GDC)

- GDC is a strategic, Living With a Star (LWS) mission that will accomplish breakthroughs in fundamental understanding of the processes that govern the dynamics of the Earth's upper atmospheric envelope that surrounds and protects the planet
- The GDC mission addresses two overarching science goals:
 1. Understand how the high latitude ionosphere-thermosphere system responds to variable solar wind/magnetosphere forcing
 2. Understand how internal processes in the global ionosphere/thermosphere system redistribute mass, momentum, and energy

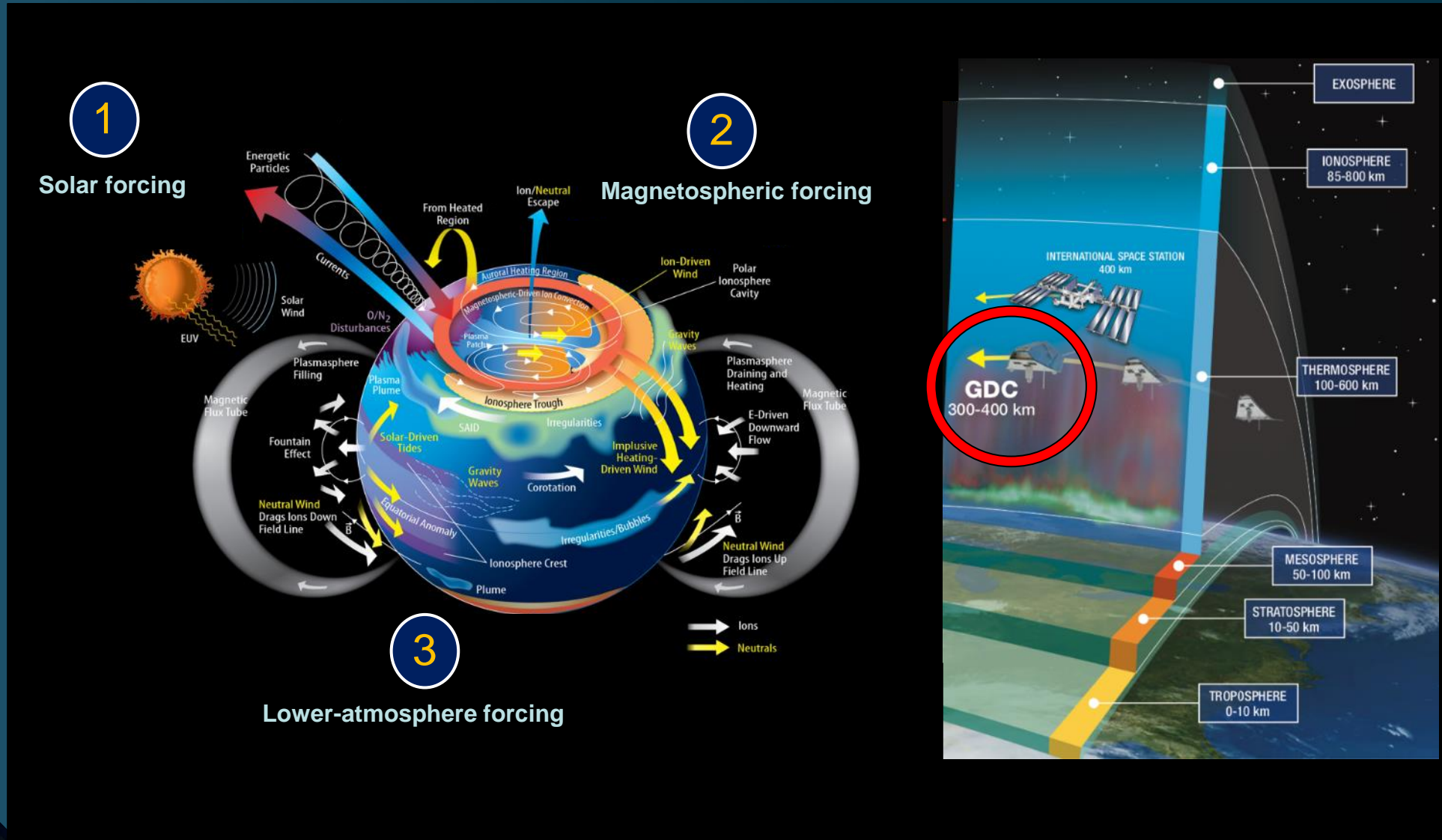
The Science of GDC

- Space-based observations have revolutionized lower-atmosphere forecasting.
- Weather satellites have given us a truly global view of tropospheric / stratospheric weather, leading to a scientific and forecasting revolution.



The Science of GDC

- GDC will similarly transform our understanding of weather in the upper atmosphere



The Science of GDC

- GDC uses the upper atmosphere as a “natural laboratory” for understanding our home and other worlds

1) Heliophysics Science

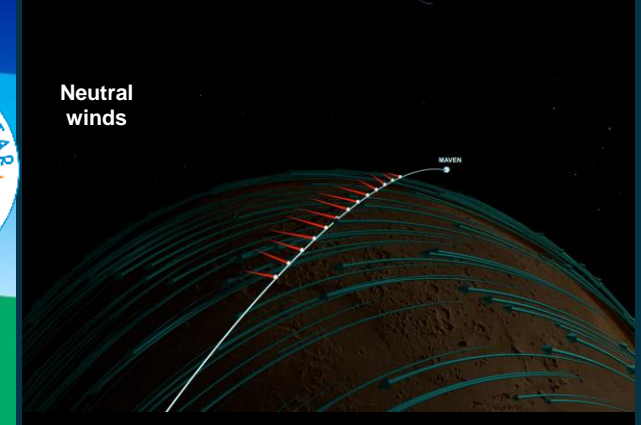
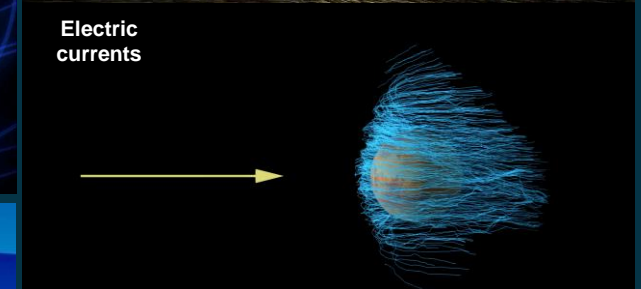
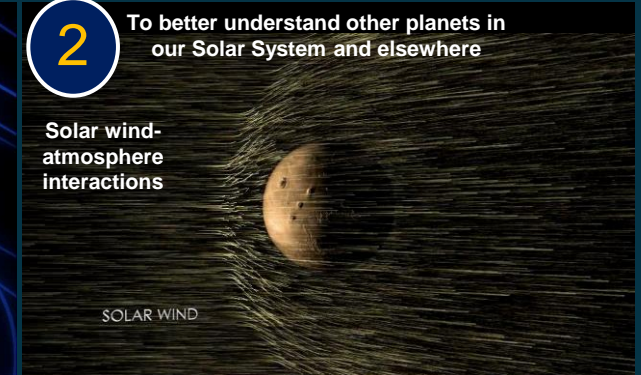
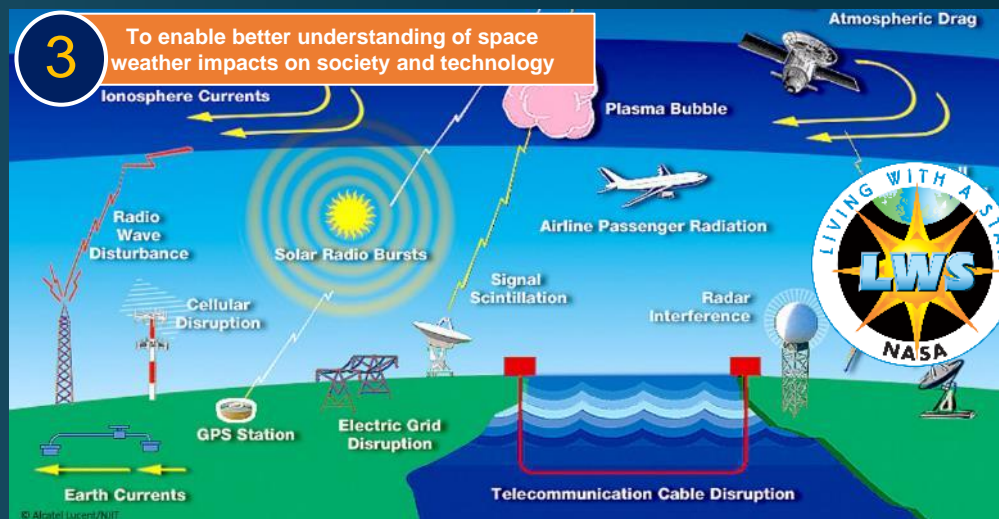
- Two-way magnetosphere-atmosphere coupling
- Universal physics of neutral gas + magnetized plasma (“natural laboratory”)

2) Comparative Planetology

- Solar wind – atmosphere interactions
- Ion-neutral interactions at other planets

3) Space Weather

- Cell, GPS, and other radio propagation
- Orbital drag
- Geoelectric current impacts on power grids



A dark blue background with a curved, abstract shape on the left side. Inside this shape, there are images of celestial bodies: a yellow planet with rings (Saturn) at the top, a reddish planet (Mars) in the middle, and a grey, cratered planet (the Moon) at the bottom. The background is filled with stars and a nebula.

NASA Space Weather Strategy

Vision

- Advance the science of space weather to empower a technological society safely thriving on Earth and expanding into space.

Mission

- Establish a preeminent space weather capability that supports robotic and human space exploration and meets national, international, and societal needs by advancing measurement and analysis techniques, and by expanding knowledge and understanding for transitioning into improved operational space weather forecasts and nowcasts.

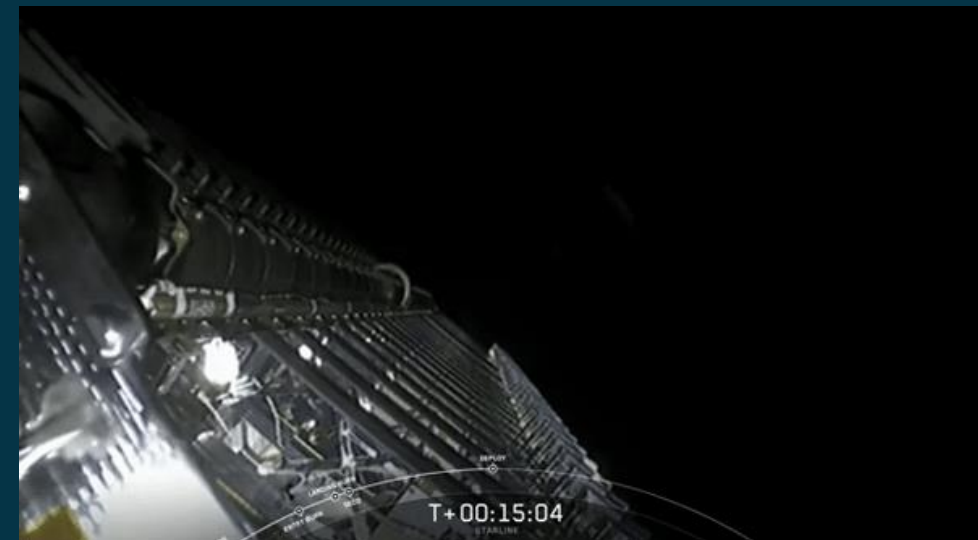
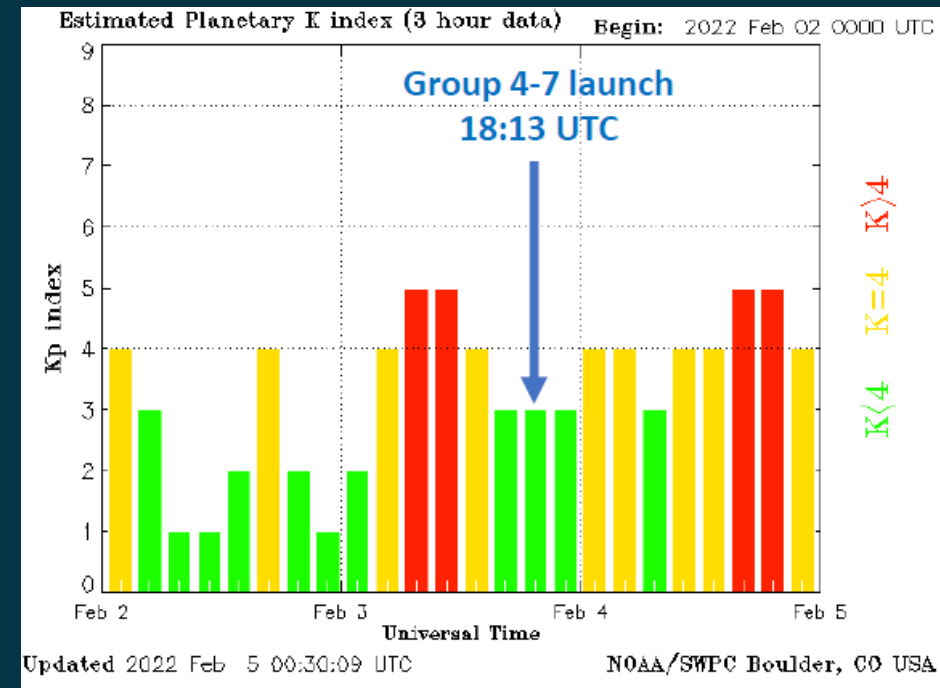
Recent Starlink Event

Overview of Event

- CME (Coronal Mass Ejection) on Jan 29, 2022 @ 23:36Z
- Within hours, NOAA and NASA had identified this CME, tracked it and analyzed it
- CME drove significant energy input into upper atmosphere, substantially changing the orbital drag environment
- SpaceX launched the Starlink satellites ~12 hours into the storm, after the thermosphere had undergone significant heating and expansion, raising the orbital drag environment significantly
- The satellites were not designed to operate in this environment and had limited delta-v capability to overcome the drag. Their orbits degraded and they re-entered Earth's atmosphere, resulting in a projected loss of 40 satellites, and \$12-24M in financial losses plus launch costs

Takeaways

- This was a minor storm.
 - Current frequency of storms this size: ~1/month
 - More frequent, larger storms will happen as we approach solar max (est. 2025)
- Had there been real-time data from a mission like GDC available, the spacecraft operator would have seen 50% density increase outside their past performance history envelope and presumably delayed the launch.





The background of the slide features a vibrant space scene. On the left, a bright yellow sun is partially visible, casting a glow over a blue and white Earth horizon. Above the Earth, a crescent moon is shown. Further up, a reddish-brown planet (Mars) and a yellow planet with a ring system (Saturn) are visible against a deep blue space filled with stars and nebulae. A large, dark blue curved shape frames the right side of the slide.

DYNAMIC, Science

- DYNAMIC is a Solar Terrestrial Probes mission to resolve key science objectives about how lower atmosphere variability affects geospace, including but not limited to
 - Day-to-day and longer-term variations
 - Multi-scale responses to energy inputs
 - Preconditioning the upper atmosphere to magnetosphere drivers
- DYNAMIC will strategically advance heliophysics science
 - Disentangle different atmospheric waves
 - Identify and characterize
- DYNAMIC has strong synergy with GDC, both scientifically and in terms of implementation details [see next slide]

Heliophysics Big Year



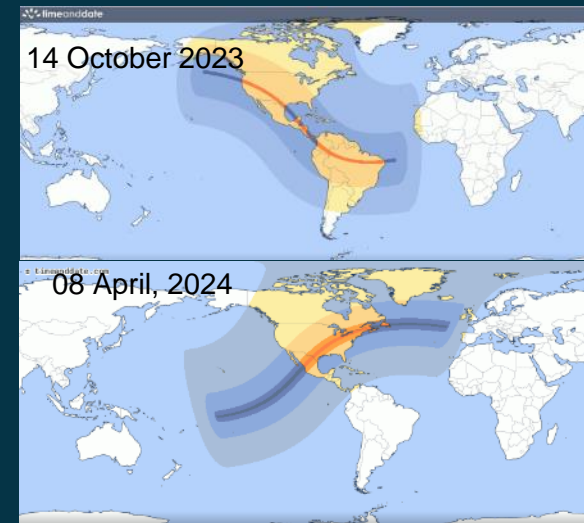
Ties together three major Heliophysics events in 2023-2025 (2 solar eclipses, solar maximum) to maximize participation in a coordinated incentivized citizen science campaign.

- NASA is developing a program to use these remarkable events to highlight and motivate solar system science
 - Two Solar Eclipses cross N. America (14 Oct 2023 and 8 April 2024)
 - The rising phase of the Solar Cycle 25 with Solar Maximum predicted to occur in 2025
- Look out for opportunities to be part of our Big Year

<https://science.nasa.gov/heliophysics/programs/citizen-science>



Totality during the solar eclipse in Australia's Tropical North Queensland on November 14, 2012. Getty Images.



The paths of totality for total solar eclipses during the HBV.

What is a “Big Year”? A big year is a birding term for maximizing a birder’s number of species.

Get Involved and Stay Informed!

We are continuing to work hard to grow the Heliophysics community, especially at a time where we find ourselves so separated. Stay in touch and help us find new ways to highlight your work and keep you in the loop!

Check out our “Nicky Notes” email!

- Sign up for it at <https://bit.ly/2R1w8HT>

Stay up to date with what’s happening at Headquarters:

- <https://science.nasa.gov/researchers/virtual-townhall-2020>

Let us know what you’ve been working on:

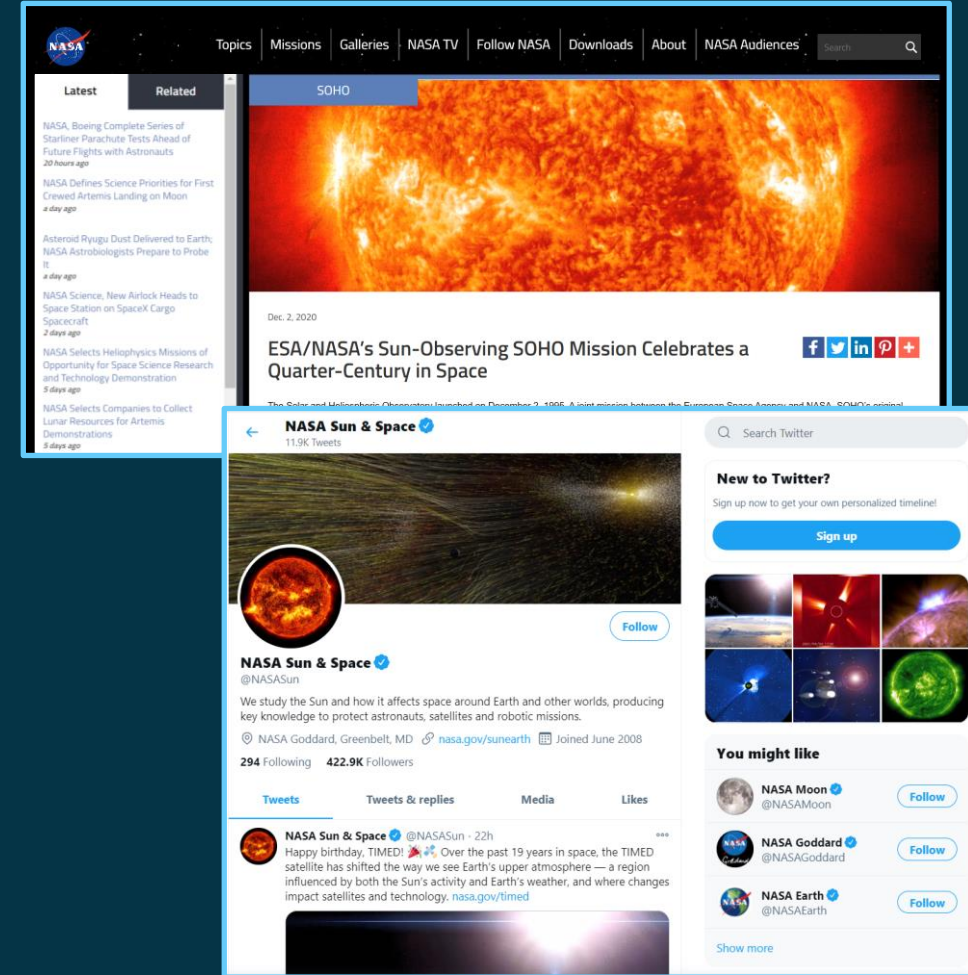
- <https://bit.ly/SubmitHelioScience>

Web and social media:

- NASA.gov/sunearth
- blogs.nasa.gov/sunspot
- @NASASun
- facebook.com/NASASunScience

Volunteer for a panel:

- <https://science.nasa.gov/researchers/volunteer-review-panels>



The background of the slide is a composite of two cosmic images. The top half features a dark space filled with numerous small, distant stars and a prominent, wispy blue nebula on the right side. The bottom half shows a similar starry field but with a large, vibrant orange and yellow nebula on the left, transitioning into a greenish-blue hue towards the right. A solid dark blue horizontal band runs across the middle of the image, serving as a backdrop for the text.

#HelioRocks!

The background of the slide is a cosmic scene. The top half features a dark blue space with a bright blue nebula on the right and numerous small, distant stars. The bottom half is a solid dark blue band containing the word 'Backup' in white. Below this band, the background transitions to a warm orange and yellow glow, with a greenish-yellow nebula on the right and more stars.

Backup